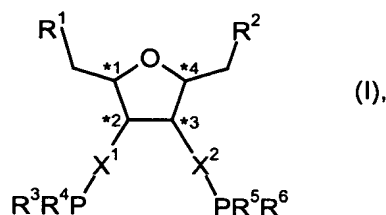


IN THE CLAIMS:

1. Compounds of the formula (I),



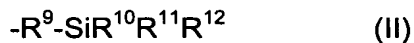
where

*1, *2, *3 and *4 are each independently a stereogenic carbon atom which is in the R- or S- configuration,

X¹ and X² are each independently absent or are oxygen and

R¹ and R² may each independently be: hydrogen, C₁-C₂₀-alkyl, C₁-C₂₀-fluoroalkyl, C₂-C₂₀-alkenyl, C₄-C₂₄-aryl, C₅-C₂₅-arylalkyl, C₆-C₂₆-arylalkenyl or NR⁷R⁸, OR⁸, -(C₁-C₈-alkyl)-OR⁸, -(C₁-C₈-alkyl)-NR⁷R⁸ or -O₂CR⁸ where R⁷ and R⁸ are each independently C₁-C₈-alkyl, C₅-C₁₄-arylalkyl or C₄-C₁₅-aryl, or R⁷ and R⁸ together are a cyclic amino radical having a total of 4 to 20 carbon atoms,

or R¹ and R² are each independently radicals of the formula (II)



where

R^9 is absent, or is oxygen or methylene and

R^{10} , R^{11} and R^{12} are each independently C_1 - C_{12} -alkyl, C_5 - C_{15} -arylalkyl or C_4 - C_{14} -aryl and

5

R^3 , R^4 , R^5 and R^6 are each independently R^{13} , OR^{14} or $NR^{15}R^{16}$ where R^{13} , R^{14} , R^{15} and R^{16} are each independently C_1 - C_{12} -alkyl, C_5 - C_{15} -arylalkyl or C_4 - C_{14} -aryl, or $NR^{15}R^{16}$ together is a cyclic amino radical having 4 to 20 carbon atoms, or R^3 and R^4 and/or R^5 and R^6 in each case together are $-O-R^{17}-O-$ where R^{17} is a radical selected from the group of C_2 - C_4 -alkylene, 1,2-phenylene, 1,3-phenylene, 1,2-cyclohexylene, 1,1'-ferrocenylene, 1,2-ferrocenylene, 2,2'-(1,1'-binaphthylene), 2,2'-(1,1')-biphenylene and 1,1'-(diphenyl-2,2'-methylene)-diyl, and the radicals mentioned may optionally be mono- or polysubstituted by radicals selected from the group of fluorine, chlorine, C_1 - C_8 -alkoxy and C_1 - C_8 -alkyl.

10

15

20 2. Compounds according to Claim 1, where, in formula (I), $*^1, *^2, *^3, *^4$ together define the following stereoisomers of the central substituted furan ring:

25

(1R,2R,3R,4R), (1R,2R,3R,4S), (1R,2R,3S,4S), (1R,2S,3S,4S),
(1R,2S,3R,4S), (1R,2S,3S,4R), (1R,2R,3S,4R), (1S,2S,3R,4S),
(1S,2S,3S,4S), (1S,2S,3S,4R), (1S,2S,3R,4R), (1S,2R,3R,4R),
(1S,2R,3S,4R), (1S,2R,3R,4S), (1S,2S,3R,4S), (1R,2R,3S,4R).

30

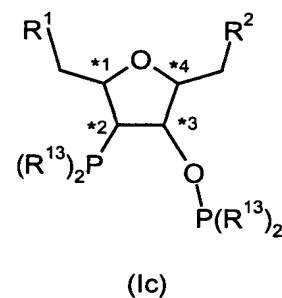
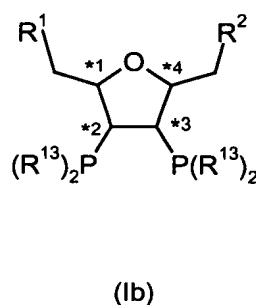
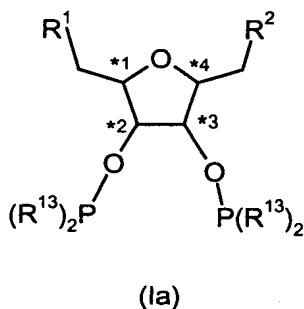
3. Compounds according to Claim 1, characterized in that, in formula (I), R^1 and R^2 are each independently hydrogen, C_1 - C_4 -alkyl, C_4 - C_{14} -aryl, $O-R^8$, O_2C-R^8 where R^8 is C_1 - C_{12} -alkyl, C_5 - C_{25} -arylalkyl or

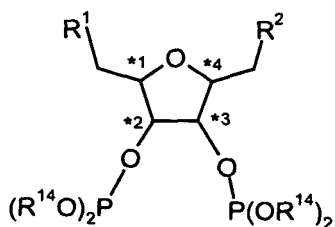
C_4 - C_{14} -aryl, or $OSiR^{10}R^{11}R^{12}$, and R^{10} , R^{11} , and R^{12} are each independently C_1 - C_{12} -alkyl or C_4 - C_{14} -aryl.

4. Compounds according to Claim 1, characterized in that, in formula (I), R^1 and R^2 are each independently hydrogen, tert-butoxy, trityloxy, tert-butyldimethylsilyloxy, tert-butyldiphenylsilyloxy, trimethylsilyloxy, triethylsilyloxy, triisopropylsilyloxy, neopentoxy or 1-adamantoxy.
5. Compounds according to Claim 1, characterized in that, in formula (I), R^3 , R^4 , R^5 and R^6 are each independently R^{13} , OR^{14} or $NR^{15}R^{16}$ where R^{13} , R^{14} , R^{15} and R^{16} are each independently C_1 - C_{12} -alkyl or C_4 - C_{14} -aryl, or $NR^{15}R^{16}$ together is a cyclic amino radical having 4 to 12 carbon atoms, or R^3 and R^4 and/or R^5 and R^6 together are each $-O-R^{17}-O-$ where R^{17} is ethylene, 1,2-phenylene, 1,3-phenylene, 1,2-cyclohexylene, 1,1'-ferrocenylene, 1,2-ferrocenylene, di- or tetra- C_1 - C_8 -alkyl-substituted 1,1'-(diphenyl-2,2'-methylene)-diyl, 2,2'-(1,1'-binaphthylene) or 2,2'-(1,1')-biphenylene, and 2,2'-(1,1'-binaphthylene) or 2,2'-(1,1')-biphenylene is substituted at least in the 6,6'-position by radicals selected from the group of C_1 - C_8 -alkoxy and C_1 - C_8 -alkyl, and may also be substituted in the 5,5', 4,4', 3,3'- or 2,2'-position by radicals selected from the group of fluorine, chlorine, C_1 - C_8 -alkoxy and C_1 - C_8 -alkyl.
6. Compounds according to Claim 1, characterized in that, in formula (I), R^3 , R^4 , R^5 and R^6 are each independently R^{13} , OR^{14} or $NR^{15}R^{16}$, where R^{13} and R^{14} are each independently methyl, ethyl, n-propyl, isopropyl, tert-butyl, cyclohexyl, phenyl, 2-(C_1 - C_8)-alkylphenyl, 3-(C_1 - C_8)-alkylphenyl, 4-(C_1 - C_8)-alkylphenyl, 2,6-di-(C_1 - C_8)-alkylphenyl, 3,5-di-(C_1 - C_8)-alkylphenyl, 2,4-di-(C_1 - C_8)-alkylphenyl, 3,4,5-tri-(C_1 - C_8)-alkylphenyl, 2-(C_1 - C_8)-alkoxyphenyl, 3-(C_1 - C_8)-

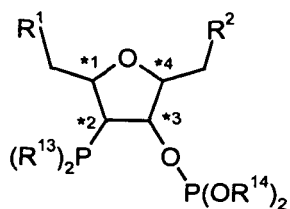
alkoxyphenyl, 4-(C₁-C₈)-alkoxyphenyl, 2,4-di-(C₁-C₈)-alkoxyphenyl, 2,6-di-(C₁-C₈)-alkoxyphenyl, 3,5-di-(C₁-C₈)-alkoxyphenyl, 3,4,5-tri-(C₁-C₈)-alkoxyphenyl, 3,5-dialkyl-4-(C₁-C₈)-alkoxyphenyl, 3,5-(C₁-C₈)-dialkyl-4-di-(C₁-C₈)-alkylaminophenyl, 4-di-(C₁-C₈)-alkylaminophenyl, 3,5-bis-((C₁-C₄)-fluoroalkyl), 2,4-bis-((C₁-C₄)-fluoroalkyl)phenyl, 4-((C₁-C₄)-fluoroalkyl)phenyl and mono-, di-, tri- or tetra-fluorine- and/or -chlorine-substituted phenyl, fluorenyl or naphthyl or NR¹⁵R¹⁶ as a whole is dimethylamino, diethylamino, pyrrolidino or diisopropylamino or R³ and R⁴ and/or R⁵ and R⁶, each in pairs, are O-R¹⁷-O where R¹⁷ is 1,1'-bis-(4,6-di-(C₁-C₈)-alkyl)-phenyl)-2,2'-methylene)-diyl or where R¹⁷ is (R)-1,1'-biphenyl-2,2'-diyl, (S)-1,1'-biphenyl-2,2'-diyl, (R)-1,1'-binaphthyl-2,2'-diyl, (S)-1,1'-binaphthyl-2,2'-diyl, 1,1'-[bis-(4-methyl-6-tert-butylphenyl)-2,2'-methylene]-diyl or 1,1'-[bis-(4-methyl-6-(1-methylcyclohexyl)-2,2'-methylene)-diyl].

7. Compounds according to Claim 1, characterized in that, in formula (I), R³ and R⁴ and/or R⁵ and R⁶ in pairs are identical.
8. Compounds according to Claim 1, characterized in that they are of formula (Ia) to (Ii)

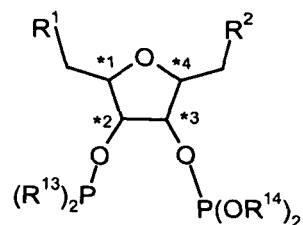




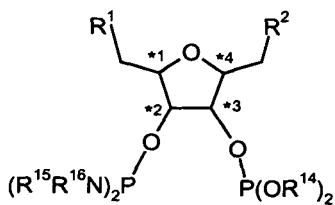
(Id)



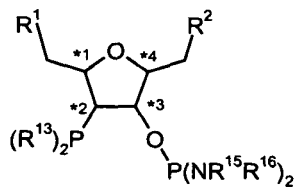
(Ie)



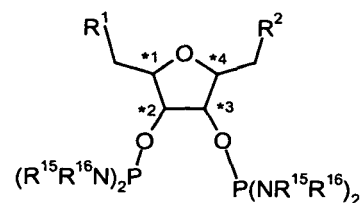
(If)



(Ig)



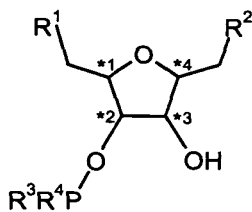
(Ih)



(Ii)

5 where $*1, *2, *3, *4, R^1, R^2, R^{13}, R^{14}, R^{15}$ and R^{16} are each as defined under formula (I) in Claim 1.

9. Compounds of the formula (XIII),



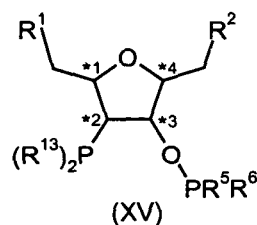
(XIII)

where R^1, R^2, R^3 and R^4 are each as defined under formula (I) in Claim 1.

15 10. Compounds selected from the group consisting of 2,3-bis-O-(Diphenylphosphino)-1,6-di-O-(triphenylmethyl)-2,5-anhydro-D-mannitol, 2,3-bis-O-(diphenylphosphino)-1,6-dideoxy-2,5-anhydro-

D-mannitol, 2,3-bis-O-(diphenylphosphino)-1,6-di-O-(*tert*-butyldiphenylsilyl)-2,5-anhydro-D-mannitol, 2,3-bis-O-(diphenylphosphino)-1,6-di-O-(triphenylmethyl)-2,5-anhydro-L-iditol, 2,3-bis-O-(diphenylphosphino)-1,6-di-O-(*tert*-butyldiphenylsilyl)-2,5-anhydro-L-iditol, 2,3-bis-O-(diphenylphosphino)-1,6-dideoxy-2,5-anhydro-L-iditol, 2,3-bis-O-(di(4-methoxyphenyl)phosphino)-1,6-di-O-(*tert*-butyldiphenylsilyl)-2,5-anhydro-D-mannitol, 2,3-bis-O-(di((4-Trifluoromethyl)phenyl)phosphino)-1,6-di-O-(*tert*-butyldiphenylsilyl)-2,5-anhydro-D-mannitol, 2-O-(di(2,4-dimethylphenyl)phosphino)-3-O-(diphenylphosphino)-1,6-di-O-(*tert*-butyldiphenylsilyl)-2,5-anhydro-D-mannitol, 2-O-(di(2,4-dimethylphenyl)phosphino)-3-O-(4,8-ditert-butyl-2,10-dimethyl-12H-dibenzo-[δ,γ][1,3,2]dioxaphosphocino)-1,6-di-O-(*tert*-butyldiphenylsilyl)-2,5-anhydro-D-mannitol and 2-O-(di(2,4-dimethylphenyl)phosphino)-3-O-(2,10-dimethyl-4,8-bis(1-methylcyclohexyl)-12H-dibenzo[δ,γ]-[1,3,2]dioxaphosphocino)-1,6-di-O-(*tert*-butyldiphenylsilyl)-2,5-anhydro-D-mannitol.

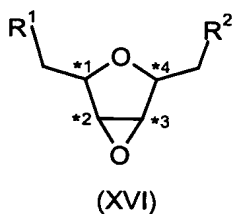
11. Process for preparing compounds of the formula (XV)



where R^1 , R^2 , R^5 , R^6 and R^{13} are each as defined under formula (I) in Claim 1, comprising t,

in step a)

converting compounds of the formula (XVI)



5 where R¹ and R² are each defined under formula (I) in Claim 1, in the presence of compounds of the formula (XVII)



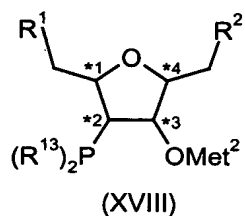
10 where

Met² is lithium, sodium or potassium and

R¹³ is as defined under formula (I) in Claim 1,

15

to compounds of the formula (XVIII)



20 where R¹, R², Met² and R¹³ are as defined above,

and, in step b),

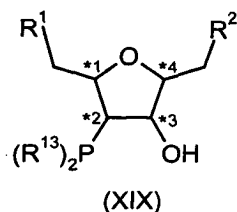
reacting the compounds of the formula (XVIII) with compounds of the formula (XIb)



where R^5 and R^6 are each as defined under formula (I) in Claim 1 and

Y is chlorine, bromine, iodine, dimethylamino or diethylamino, to give compounds of the formula (XV).

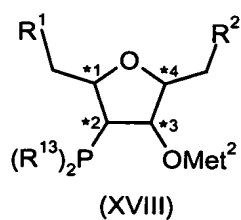
12. Process according to Claim 11, characterized in that the compounds of the formula (XVII) are converted by acidifying to compounds of the formula (XIX)



and, in step b), are converted by reacting with compounds of the formula (XIb) to compounds of the formula (XV).

13. Process according to Claim 12, characterized in that step b) is carried out in the presence of a base.

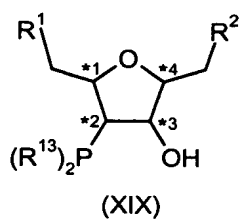
14. Compounds of the formula (XVIII)



where R^1 , R^2 and R^{13} are each as defined under formula (I) in Claim 1 and Met^2 is as defined under formula (XVII) in Claim 10.

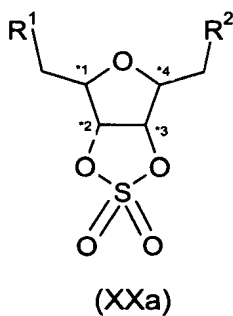
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15. Compounds of the formula (XIX)



10 where R^1 , R^2 and R^{13} are each as defined under formula (I) in Claim 1.

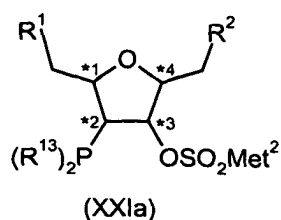
16. Compounds of the formula (XXa)



15

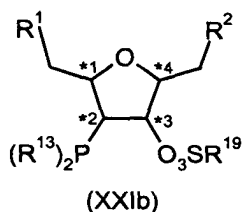
where R^1 and R^2 are each as defined under formula (I) in Claim 1.

20 17. Compounds of the formula (XXIa),



where R^1 , R^2 and R^{13} are each as defined under formula (I) in Claim 1 and Met^2 is as defined under formula (XVII) in Claim 10.

18. Compounds of the formula (XXIb),



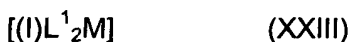
where R^1 , R^2 and R^{13} are each as defined under formula (I), and R^{19} is C_1 - C_{12} -alkyl, C_1 - C_{12} -fluoroalkyl, C_5 - C_{25} -arylalkyl or C_4 - C_{24} -aryl.

19. Transition metal complexes containing compounds according to Claim 1.

20. Transition metal complexes according to Claim 19, characterized in that the transition metal is selected from the group of ruthenium, osmium, cobalt, rhodium, iridium, nickel, palladium, platinum and copper.

21. Transition metal complexes according to Claim 19, characterized in that the molar ratio of transition metal to compounds of Claim 1 is 1:1.

22. Transition metal complexes according to Claim 20, characterized in that they obey the formula (XXIII)



5

where (I) represents a compound of the formula (I) as defined in Claim 1 and

10

M is rhodium or iridium and

L^1 is in each case a C_2 - C_{12} -alkene or a nitrile or

L^1_2 together is a (C_4 - C_{12})-diene.

15

23. [Rh(cod)(2,3-bis-O-(diphenylphosphino)-1,6-di-O-(triphenylmethyl)-2,5-anhydro-D-mannitol)]BF₄, [Rh(cod)(2,3-bis-O-(diphenylphosphino)-1,6-di-O-(*tert*-butyldiphenylsilyl)-2,5-anhydro-D-mannitol)]BF₄, [Rh(cod)(2,3-bis-O-(diphenylphosphino)-1,6-dideoxy-2,5-anhydro-D-mannitol)]BF₄ and [Ir(cod)(2,3-bis-O-(diphenylphosphino)-1,6-di-O-(*tert*-butyldiphenylsilyl)-2,5-anhydro-D-mannitol)]BF₄.

20

24. Transition metal complexes according to Claim 19, characterized in that they are obtained by reacting transition metal compounds and compounds according to Claim 1.

25

25. Transition metal complexes according to Claim 24, characterized in that the transition metal compounds used are:

30

transition metal compounds of the formula (XXIIa)



where

5 M is rhodium, iridium, ruthenium, nickel, palladium, platinum or copper and

 An¹ is chloride, bromide, acetate, nitrate, methanesulphonate, trifluoromethanesulphonate or acetylacetonate and

10

 q is 3 for rhodium, iridium and ruthenium, is 2 for nickel, palladium and platinum, and is 1 for copper,

or transition metal compounds of the formula (XXIIb),

15



where

20 M is rhodium, iridium, ruthenium, nickel, palladium, platinum or copper and

 An² is chloride, bromide, acetate, methanesulphonate or trifluoromethanesulphonate, tetrafluoroborate or
25 hexafluorophosphate, perchlorate, hexafluoroantimonate, tetra(bis-3,5-trifluoromethylphenyl)borate or tetraphenylborate and

 q is 1 for rhodium and iridium, is 2 for ruthenium, nickel,
30 palladium and platinum, and is 1 for copper,

L^1 is in each case a C_2 - C_{12} -alkene or

L^1_2 together is a (C_4 - C_{12})-diene

5 or transition metal compounds of the formula (XXIIc)



where

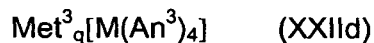
10

M is ruthenium and

L^2 is an aryl radical or cyclooctadiene, norbornadiene or
methylallyl

15

or transition metal compounds of the formula (XXIId)



20

where

M is palladium, nickel, iridium or rhodium and

An^3 is chloride or bromide and

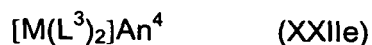
25

Met^3 is lithium, sodium, potassium, ammonium or organic
ammonium and

q is 3 for rhodium and iridium, and is 2 for nickel, palladium
and platinum,

30

or transition metal compounds of the formula (XXIIe)



5 where

M is iridium or rhodium and

10 L^3 is (C₄-C₁₂)-diene and

An^4 is a noncoordinating or weakly coordinating anion

or

15 Ni(1,5-cyclooctadiene)₂, Pd₂(dibenzylideneacetone)₃, Pd[PPh₃]₄,
cyclopentadienyl₂Ru, Rh(acac)(CO)₂, Ir(pyridine)₂(1,5-cyclo-
octadiene), Cu(phenyl)Br, Cu(phenyl)Cl, Cu(phenyl)I, Cu(PPh₃)₂Br,
[Cu(CH₃CN)₄]BF₄ and [Cu(CH₃CN)₄]PF₆ or multinuclear bridged
complexes, for example [Rh(1,5-cyclooctadiene)Cl]₂, [Rh(1,5-
20 cyclooctadiene)Br]₂, [Rh(ethene)₂Cl]₂ or [Rh(cyclooctene)₂Cl]₂.

26. Transition metal complexes according to Claim 25, characterized in
that the transition metal compounds used are: [Rh(cod)Cl]₂,
[Rh(cod)Br]₂, [Rh(cod)₂]ClO₄, [Rh(cod)₂]BF₄, [Rh(cod)₂]PF₄,
25 [Rh(cod)₂]ClO₆, [Rh(cod)₂]OTf, [Rh(cod)₂]BAr₄ (Ar = 3,5-
bistrifluoromethylphenyl), [Rh(cod)₂]SbF₆, RuCl₂(cod),
[(cymene)RuCl₂]₂, [(benzene)RuCl₂]₂, [(mesityl)RuCl₂]₂,
[(cymene)RuBr₂]₂, [(cymene)RuI₂]₂, [(cymene)Ru(BF₄)₂]₂,
[(cymene)Ru(PF₆)₂]₂, [(cymene)Ru(BAr₄)₂]₂ (Ar = 3,5-bistrifluoro-
30 methylphenyl), [(cymene)Ru(SbF₆)₂]₂, [Ir(cod)Cl]₂, [Ir(cod)₂]PF₆,
[Ir(cod)₂]ClO₄, [Ir(cod)₂]SbF₆, [Ir(cod)₂]BF₄, [Ir(cod)₂]OTf,

[Ir(cod)₂]BAr₄ (Ar = 3,5-bistrifluoromethylphenyl), RuCl₃, NiCl₃,
 RhCl₃, PdCl₂, PdBr₂, Pd(OAc)₂, Pd₂(dibenzylideneacetone)₃,
 Pd(acetylacetonate)₂, CuOTf, CuI, CuCl, Cu(OTf)₂, CuBr, CuI,
 CuBr₂, CuCl₂, CuI₂, [Rh(nbd)Cl]₂, [Rh(nbd)Br]₂, [Rh(nbd)₂]ClO₄,
 5 [Rh(nbd)₂]BF₄, [Rh(nbd)₂]PF₆, [Rh(nbd)₂]OTf, [Rh(nbd)₂]BAr₄ (Ar =
 3,5-bistrifluoromethylphenyl), [Rh(nbd)₂]SbF₆, RuCl₂(nbd),
 [Ir(nbd)₂]PF₆, [Ir(nbd)₂]ClO₄, [Ir(nbd)₂]SbF₆, [Ir(nbd)₂]BF₄,
 [Ir(nbd)₂]OTf, [Ir(nbd)₂]BAr₄ (Ar = 3,5-bistrifluoromethylphenyl),
 Ir(pyridine)₂(nbd), [Ru(DMSO)₄Cl₂], [Ru(CH₃CN)₄Cl₂],
 10 [Ru(PhCN)₄Cl₂], [Ru(cod)Cl₂]_n, [Ru(cod)₄(methallyl)₂],
 [Ru(acetylacetonate)₃].

27. Transition metal complexes according to Claim 26, characterized in
 that the transition metal compounds used are:

15 [Rh(cod)Cl]₂, [Rh(cod)Br]₂, [Rh(cod)₂]ClO₄, [Rh(cod)₂]BF₄,
 [Rh(cod)₂]PF₆, [Rh(cod)₂]ClO₆, [Rh(cod)₂]OTf, [Rh(cod)₂]BAr₄ (Ar =
 3,5-bistrifluoromethylphenyl), [Rh(cod)₂]SbF₆, [Rh(nbd)Cl]₂,
 [Rh(nbd)Br]₂, [Rh(nbd)₂]ClO₄, [Rh(nbd)₂]BF₄, [Rh(nbd)₂]PF₆,
 20 [Rh(nbd)₂]OTf, [Rh(nbd)₂]BAr₄ (Ar = 3,5-bistrifluoromethylphenyl),
 [Rh(nbd)₂]SbF₆, [Ir(cod)Cl]₂, [Ir(cod)₂]PF₆, [Ir(cod)₂]ClO₄,
 [Ir(cod)₂]SbF₆, [Ir(cod)₂]BF₄, [Ir(cod)₂]OTf, [Ir(cod)₂]BAr₄ (Ar = 3,5-
 bistrifluoromethylphenyl).

25 28. Transition metal complexes according to Claim 23, characterized in
 that the amount of the transition metal compounds used is 25 to
 200 mol%, based on the compound according to Claim 1.

29. A process for preparing stereoisomerically enriched compounds
 30 comprising providing transition metal complexes of Claim 19.

30. The process according to Claim 29, characterized in that the stereoisomerically enriched compounds are obtained by asymmetric 1,4-additions, asymmetric hydroformylations, asymmetric hydrocyanations, asymmetric Heck reactions and asymmetric hydrogenations.
31. A process for preparing active ingredients in pharmaceuticals and agrochemicals, or intermediates of these two classes comprising providing stereoisomerically enriched compounds of Claim 29.
32. A process for catalyzing reactions comprising providing metal complexes according to Claim 19.
33. Process for preparing stereoisomerically enriched compounds by catalytic hydrogenations of olefins, enamines, enamides, imines or ketones, 1,4-additions, hydroformylations, hydrocyanations or Heck reactions, characterized in that the catalysts used are those which comprise transition metal complexes according to Claim 19.
34. Process according to Claim 33, characterized in that the amount of the transition metal complexes used is 0.001 to 5 mol%, based on the substrate used.
35. Process according to Claim 33, characterized in that the stereoisomerically enriched compounds are obtained by catalytic hydrogenation of olefins, enamides or imines.
36. Process according to Claim 33, characterized in that the working temperature is -20°C to 200°C .

37. Process according to Claim 34, characterized in that the hydrogen pressure is 0.1 to 200 bar.

38. Catalysts comprising transition metal complexes according to Claim 19.